MEMORANDUM

TO: TECHNICAL ADVISORY COMMITTEE

FROM: CHERYL JENKINS, PROJECT MANAGER and SAM DENT, TECHNICAL LEAD - VEIC

SUBJECT: TRM VERSION 5 DRAFT 1 REVIEW – SECOND MEASURE GROUP

DATE: 11/25/15

Cc: ANNETTE BEITEL, SAG

VEIC has submitted the second group of measure edits and new measures for review by the Technical Advisory Committee. This draft is not a complete TRM and only has the new measures or redlines of the remaining sections and measures that have been worked on and discussed at the TAC meetings to date. The first full draft of the v5.0 TRM will be provided on December 18th, 2015.

Presented below are two summary tables. The first provides the measures found in this second submitted group with a brief description of what has changed, whether it is being considered an errata, and a link to the corresponding SharePoint Tracker Item(s).

Measure # and Name		Errata?	Brief description of what changed	Tracker Item(s)
4.2.1	Combination Oven	N	Re-write using algorithms rather than deemed savings. Standard updates. Added electric combination ovens.	Update Deemed values from Nicor 2011-2014 plan
4.2.11	High Efficiency Pre-Rinse Spray Valve	N	Added reference to IECC 2015	Incorporate IECC2015 Code Changes
4.3.5	Tankless Water Heater	N	Added reference to IECC 2015	Incorporate IECC2015 Code Changes
4.3.7	Multifamily Central Domestic Hot Water Plants	N	Added reference to IECC 2015	Incorporate IECC2015 Code Changes
4.4.2	Space Heating Boiler Tune Up	N	Added clarifying language on appropriate firing rates for combustion efficiency testing.	Clarification of Boiler Tune-Up Combustion Efficiency
4.4.3	Process Boiler Tune Up	N	Added clarifying language on appropriate firing rates for combustion efficiency testing.	Clarification of Boiler Tune-Up Combustion Efficiency
4.4.6	Electric Chiller	N	Added specifications for IECC 2015 Updated cost assumptions	Incorporate IECC2015 Code Changes
4.4.7	Lighting Power Density	N	Added specifications for IECC 2015	Incorporate IECC2015 Code Changes
4.4.9	Heat Pump Systems	N	Added specifications for IECC 2015	Incorporate IECC2015 Code Changes

Measure # and Name		Errata?	Brief description of what changed	Tracker Item(s)
4.4.11	High Efficiency Furnace	N	Update of Heating Fan hour assumptions VEIC plan to develop CFs for the fan savings from this measure also.	Update Pump and Fan Hours assumption
4.4.13	PTAC and PTHP	N	Added specifications for IECC 2015	Incorporate IECC2015 Code Changes
4.4.15	Single-Package and Split System Unitary AC	N	Added specifications for IECC 2015	Incorporate IECC2015 Code Changes
4.4.16	Steam Trap Replacement or Repair	N	Providing clarifying edits and secondary equations to calculate maximum steam loss. Allowing actual steam pressure and HOU entry. Update values for deemed average pressure and operating hours based on program data.	Update Deemed values from Nicor 2011-2014 plan
4.4.17	Variable Speed Drives for HVAC Pumps and Cooling Tower Fans	N	Added reference to IECC 2015	Incorporate IECC2015 Code Changes
			Updated Heating and Cooling HOU assumptions	Update Pump and Fan Hours assumption
4.4.26	Variable Speed Drives for Supply and Return Fans	N	Added reference to IECC 2015	Incorporate IECC2015 Code Changes
			Updated Heating, Cooling and Ventilation HOU assumptions	Update Pump and Fan Hours assumption
4.4.27	Energy Recovery Ventilator	N	Added reference to IECC 2015	Incorporate IECC2015 Code Changes
4.4.30	Notched V Belts for HVAC Systems	N	Updated Heating, Cooling and Ventilation HOU assumptions	Update Pump and Fan Hours assumption
4.4.31	Small Business Furnace Tune-Up	N	Added clarifying language on appropriate firing rates for combustion efficiency testing.	Clarification of Boiler Tune-Up Combustion Efficiency
NEW	Destratification Fans	N	New Measure	Thermal Equalizer Destratification Fans
NEW	Economizer Repair and Optimization	N	New Measure	HVAC Optimization (Economizer Repair & Optimization)
NEW	Multi-Family Space Heating Steam Boiler Averaging Controls	N	New Measure	Averaging Controls for Steam Pipe Systems without Thermostat Radiator Valves
NEW	Unitary HVAC Condensing Furnace	N	New Measure	High Efficiency Condensing RTUs
4.5	Lighting End Use	N	Updated HOU and CF assumptions for select building types based on IL evaluation	Non-Residential Lighting Operating Hours Data Aggregation
			Updated lighting waste heat factors (fixing	Error in Lighting IFkWh interaction factors

Measure # and Name		Errata?	Brief description of what changed	Tracker Item(s)
			autosizing issues). Updated remaining building type CFs based on eQuest models. VEIC plan to also review the model derived hours of use for the remaining building types.	WHFd - fix EQuest modeling autosizing issue Discuss if eQuest models should be used to develop C&I Lighting CFs
4.5.3	High Performance and Reduced Wattage T8 Fixtures and Lamps	N	Table review – providing nominal and ballast factor assumptions. Adding significant digits to show difference in values.	HP and RW T8 Fixtures
4.5.4	LED Bulbs and Fixtures	N	Adding incremental cost to reference tables. Updating O&M for Standard Omnidirectional lamps. Updating and consolidating reference tables.	LED Bulbs and Fixtures
4.5.9	Multi-Level Lighting Switch	N	Added reference to IECC 2015	Incorporate IECC2015 Code Changes
4.5.13	Occupancy Controlled Bi-Level Lighting Fixtures	N	Added reference to IECC 2015	Incorporate IECC2015 Code Changes
4.7.6	Roof Insulation for C&I Facilities	N	Added specifications for IECC 2015	Incorporate IECC2015 Code Changes
NEW	Cycling Compressed Air Dryer	N	New Measure	New Measure - Cycling Refrigerated Compressed Air Dryers
NEW	Modulating Commercial Gas Clothes Dryer	N	New Measure	Modulating Dryers
5.1.7	ENERGY STAR Room AC	N[1]	Update of Federal Standard and ENERGY STAR specifications ** Note this has not been discussed on a TAC call**	None
5.3.1	Air Source Heat Pump	N	Clarification of Early Replacement determination	Residential Air Conditioner Decision Tree
		N	Measure cost update	Update incremental measure costs - ASHP, CAC, ductless mini-splits
		N	Update to CF and ELFH for multifamily homes	Metered data for ASHP, Mini-split algorithm
5.3.3	Central AC	N	Clarification of Early Replacement determination	Residential Air Conditioner Decision Tree
		N	Measure cost update	Update incremental measure costs - ASHP, CAC, ductless mini-splits
5.3.6	Gas High Efficiency Boiler	N	Clarification of Early Replacement determination	Residential Air Conditioner Decision Tree

[1] Though the Federal and ENERGY STAR standards changed in August 2014 and October 2015 respectively, the impact on the savings from the existing measure is minimal and so it is considered not worth making an ERRATA.

Measure # and Name		Errata?	Brief description of what changed	Tracker Item(s)
5.3.7	Gas High Efficiency Furnace	N	Clarification of Early Replacement determination	Residential Air Conditioner Decision Tree
5.3.8	Ground Source Heat Pump	N	Clarification of Early Replacement determination	Residential Air Conditioner Decision Tree
5.3.12	Ductless Heat Pumps	N	Measure cost update	Update incremental measure costs - ASHP, CAC, ductless mini-splits
		N	Change of algorithm to be based on Capacity and EFLH as opposed to %displaced and annual load. Update to CF and ELFH. Fixing existing efficiency assumptions.	Metered data for ASHP, Mini-split algorithm
5.3.13	Residential Furnace Tune-Up	N	Added clarifying language on appropriate firing rates for combustion efficiency testing.	Clarification of Boiler Tune-Up Combustion Efficiency
New	Smart Thermostat	N	New Measure	Differentiate the Residential Programmable Thermostat Measure based on Thermostat Capabilities
5.6.1 ERRATA Version A	Air Sealing[2]	Y	Changing Latent Multiplier assumption to be based on "Controlling Indoor Humidity Using Variable-Speed Compressors and Blowers", consistent with HPWH measure	Air Sealing and Insulation Measures Adjustment Factor Update. Review TRM v metering / billing study results
5.6.1 Version A		N	Changing Latent Multiplier as above. Applying 80% adjustment factor as discussed in 11/17 TAC meeting. Adjusting default gas efficiency to 72%.	Air Sealing and Insulation Measures Adjustment Factor Update. Review TRM v metering / billing study results
		N	Adding prescriptive air sealing savings for when blower door testing is not possible	Include prescriptive residential air sealing measures
5.6.1 ERRATA Version B		Y	Changing Latent Multiplier assumption to be based on calculation of hours sensible and total loads.	None – recommendations from Bruce Harley, CLEAResult (see Appendix A).
5.6.1 Version B		N	Changing Latent Multiplier as above. Change cooling and heating n-factor values based on applying LBNL infiltration model. Revert HDD assumption back to base temperature 60F. Adjusting default gas efficiency to 72%.	None – recommendations from Bruce Harley, CLEAResult (see Appendix A).
		N	Adding prescriptive air sealing savings for when blower door testing is not possible	Include prescriptive residential air sealing measures
5.6.2	Basement Sidewall Insulation	N	Applying 80% adjustment factor to cooling savings and 60% adjustment factor to heating savings as discussed in 11/17 TAC meeting. Adjusting default gas efficiency to 72%.	Air Sealing and Insulation Measures Adjustment Factor Update. Review TRM v metering / billing study results

[2] See further explanation of Version A versus B in section below table.

Measure # and Name		Errata?	Brief description of what changed	Tracker Item(s)
5.6.3	Floor Insulation above Crawlspace	N	Applying 80% adjustment factor to cooling savings and 60% adjustment factor to heating savings as discussed in 11/17 TAC meeting. Adjusting default gas efficiency to 72%.	Air Sealing and Insulation Measures Adjustment Factor Update. Review TRM v metering / billing study results
5.6.4	Wall and Ceiling Insulation	N	Applying 80% adjustment factor to cooling savings and 60% adjustment factor to heating savings as discussed in 11/17 TAC meeting. Adjusting default gas efficiency to 72%.	Air Sealing and Insulation Measures Adjustment Factor Update. Review TRM v metering / billing study results
NEW	Tier 2 Advanced Power Strips – Residential AV	N	New Measure	Advanced Power Strip - Tier 2
NEW	Residential Behavior Change	N	New Measure	Residential Behaviour Change

5.6.1 Air sealing – Versions A and B

You will observe there are four versions of the Air Sealing measure that have been provided.

- Version A represents the changes as discussed during the 11/17 Technical Advisory Committee meeting. The Errata document fixes a clear error in the cooling algorithm with respect to the Latent Multiplier that was resulting in savings far higher than feasible. The correction is to make it consistent with the assumption used in the HPWH measure as discussed on the TAC calls. The second non-errata document provides the proposed additional changes resulting from discussions about the two years of billing analysis performed by Opinion Dynamics (as proposed on 11/17 TAC call).

- Version B is provided as an alternative set of edits based upon feedback that VEIC received, after the 11/17 meeting, from Bruce Harley from CLEAResult (a draft write up is provided in Appendix A). First the Errata fix for the latent multiplier is proposed to be based upon calculation of each hour's sensible and total loads. The impact of this change is to reduce cooling savings by approximately 50% (as opposed to the 80% from the adjustment in Version A Errata). The second non-errata document then provides the following proposed adjustments:

    - New n-factors based on applying the LBNL infiltration model directly. The new values would reduce cooling savings by approximately 35-60% and reduce heating savings by approximately 20-30% (depending on location and # stories etc).
    - Reverting the HDD assumption from using a base temperature of 65F to 60F (consistent with other shell measures). This adjustment to 65F was added in Version 2.0 of the TRM to account for savings being lower than modeling software results. Bruce Harley argues that it is not appropriate to make this arbitrary adjustment to just this measure and not other potentially less efficient shell characteristics. This change would reduce heating savings from air sealing by about 25%.
    - Not applying the 80% adjustment discussed on 11/17.

The overall impact between Version A and B is estimated to be similar on the cooling side (although the Errata impact would be less in Version B), while it is *estimated* that Version B would result in a lower heating savings (estimated to represent an adjustment of around 60%, as opposed to 80% in Version A).

VEIC have provided these two proposals for review at this time and we will discuss again in December.

This second table below provides tracker items that have not been part of the deliverables to date as they have either been closed, are repeats of other tracker items, are more general in nature, or will be tackled in the Full v5.0 Draft.

Items that will not be in 11/25 deliverable:	Comments
Updating Incremental Cost for Small Commercial Programmable Thermostats and Gas High Efficiency Furnace	Tracker item removed as per request from Bridgid Lutz, Nicor.
Res Thermostats - add furnace fan savings for homes with heat pumps	Decided to put on hold as there are concerns around programmable thermostats and heat pumps
Missing and Broken Links in TRM Sections	Improved format of reference folders. Direct linking possible by moving to web-based database.
Default Fixture Wattage Reference Table	ComEd proposed pulling all fixture wattage assumptions out of the measures and in to a master table. VEIC reviewed this request and have a more detailed response below.
Revise minimum R-value of residential insulation measures	Not implemented as algorithms already over claiming as per ODC evaluations
Standardization of Algorithm Terms	Will attempt to fix some in first full draft. Possible reliability review process.
Update ISR for aerators, showerheads, CFLs	Repeat of Tracker entry from Hammad Chaudhry (Nicor).
Compressed Air	Agreement to make separate section. Will be in first full draft 12/18
Footnote Formatting	Will be in first full draft 12/18
Improving TRM documentation, quality, transparency, and replicability	Reliability reviews will improve. Process still to be defined.
New measure request for Tier 1 commercial Advanced Power Strip	Agreement to treat as custom until more data is available.
New measure request for RES Advanced Power Strip - Tier 2	Repeat tracker entry

Default Fixture Wattage Reference Table

A request was received to add a default reference table to help determine the wattage of baseline (existing) lighting fixtures. The overall idea behind and intent of this table was to provide a single simplified reference to assign agreed upon (by both implementation and evaluation) wattage values to common baseline fixture types (fluorescent, incandescent, MH, HPS etc.) used in commercial and industrial applications throughout the IL Technical Reference Manual (TRM). It would be located in the reference section of the TRM and remove the need for baseline wattages to be listed within individual measures.

After reviewing various fixture wattage reference sources (including those provided by ComEd) and table-style options, the following key concerns became apparent:

1) Adding a master wattage table to the current IL TRM would not remove the need for similar tables within each measure that provide additional details on specific baseline options and efficient measure assumptions such as mid life adjustments, blended baselines, lumen ranges , cost and life comparisons etc. Subsequently having repetitive data throughout the TRM could actually increase the risk of error/inconsistency when updating future versions.
2) Removing baseline fixture wattage comparisons from the context of specific measures (shifting and weighted baselines (MH/CFL/T8:T12 etc.), ballast factors) could create confusion for TRM users and miscalculations of energy savings.
3) A fully-inclusive table of all baseline fixtures currently outlined in the TRM would be multiple pages in length, and may not be appropriate for inclusion in the WORD document. If/when IL move towards more of a database design, this kind of reference table becomes far more feasible and appropriate.
4) Integrating a fixture baselines wattage table to the TRM reference section is not a quick addition; it will require a complete review and revision of every lighting measure in the TRM to ensure references are set correctly, data is properly captured and used appropriately in conjunction with the other measure specific factors.

While we still in theory support the concept behind building a common set of assumptions for baseline fixtures within the IL TRM as outlined above, given these factors we felt it would behoove the TAC (given the lift necessary to effectively deliver) to re-assess the value in the proposal and if there is a clear desire discuss whether such a project should be tackled as a major development in a future revision cycle of the TRM, and also to reflect whether such a master baseline fixture table might be best situated when considering a data-based design and delivery of the TRM. We will add this to the agenda for discussion in a future Technical Advisory Committee call.

Appendix A: Bruce Harley, CLEAResult Feedback on Air Sealing Measure

Please note this is in draft form and not for distribution.

Infiltration Factor Calculation Methodology

Bruce Harley, Senior Manager, Applied Building Science, CLEAResult

11/18/2015

Preliminary DRAFT

- not for distribution -

Executive Summary

Three infiltration factors, N-heat, N-cool, and latent multiplier (LM) are commonly used in energy calculations, in contexts such as TRM measure definitions, energy auditor or home performance contractor work, and program savings reporting. This paper discusses problems with some of the factors that are in common use, and offers an analytical approach to deriving better factors using contemporary weather data, accepted infiltration models and basic psychrometric calculations. For the purpose of developing this paper, five representative weather sites were analyzed using National Climatic Data Center (NCDC) 30 year normal weather files.

Background

The first two factors are heating season and cooling season coefficients, used to convert blower door readings in units of CFM50 to estimates of natural infiltration in CFM. Commonly called "N-factors," the most commonly cited source for N-factors is a map that was originally printed in an article in Home Energy Magazine (1986) that cites the LBNL infiltration model (including wind and stack effect as driving forces) as a source. This information has been reprinted in various places, and is widely used but is both outdated and insufficient as a model for heating or cooling energy calculations. It is outdated in that a majority of energy efficiency proponents agree that the "shielding" factor is generally ignored because it results in too large an adjustment (this fact has been recognized in RESNET procedures for years, with a fixed shielding coefficient of "well shielded" to be used for all home testing). It is insufficient because it provides an annual average value for the conversion coefficient, which although it accounts for wind and annual average temperature variations (albeit with very coarse granularity), it does not account for the seasonal variations that are necessary to reasonably estimate heating and cooling loads from infiltration[3].

The third factor, latent multiplier, is used to account for the fact that outdoor air is a source of humidity during the cooling season. That humidity, removed by the mechanical equipment, represents an increased load on the cooling equipment beyond what is calculated from the infiltration model mentioned above. That infiltration model is based only on wind and stack effect, thus it is driven by the sensible component of air leakage alone, and would underestimate the cooling load due to the latent component of that air leakage. One method cited in some TRM calculations is an ASHRAE paper by Lew Harriman *et al* ("Dehumidification and Cooling Loads From Ventilation Air", *ASHRAE Journal*, Nov 1997). The paper addresses the latent component of ventilation loads in commercial HVAC systems that run continuously at fixed air flows.

[3] To illustrate the importance of this distinction, note that the largest driver of infiltration is the stack effect. Stack-driven infiltration is roughly proportional to the indoor-outdoor temperature difference. The magnitude of the average temperature difference would need to be constant throughout the year in order for the heating season and cooling season values to match the annual average. Using the annual averages for winter and summer load calculations is essentially an assumption that the outdoor temperature is constant year-round.

Although in both cases the outdoor humidity varies with weather conditions, residential infiltration rates also vary with weather conditions unlike fixed-rate commercial ventilation systems[4]. Other approaches that have been proposed include a latent multiplier based on default sensible heat ratio (SHR) for residential air-conditioning equipment (LM = 1/SHR = 1/0.75 or 1.33). This might make sense as a default (although it does not account for climate), if infiltration was the only or primary component of both sensible and latent cooling loads. However, the majority of residential cooling loads are driven from internal and solar gains, which are almost all sensible (some internal gains such as hot water use have a small latent component). So for example, if infiltration represented 1/10 of the sensible cooling load and all of the latent load (a reasonable simplification just to illustrate the concept), the LM would be ratio of the total to sensible components of the infiltration load. The latent infiltration load could be expressed as (1 - 0.75 = 0.25) of the house total load. The sensible infiltration would then be (0.1 * 0.75 = 0.075) of the house load, and the total infiltration load would be (0.25 + 0.075 = 0.325) of the house cooling load. The latent multiplier would thus be (0.325/0.075 = 4.33). Actually, this value is pretty close to the number that was obtained analytically from hourly data for the five Illinois sites that were analyzed for this project.

Hourly Methodology for N-factors

A better approach for estimating climate-specific N-factors is to simply apply the LBNL infiltration model to the reported wind speeds and outdoor temperatures. Equation (1) shows the calculation to estimate natural infiltration in CFM for each CFM50 of measured building shell leakage.

$$\frac{CFM}{CFM50} = \sqrt{{f_s}^2|68 - T| + {f_w}^2{v_w}^2} \times \frac{60\times 0.055}{144} \qquad (1)$$

[The derivation of this formula will be developed further but it is documented in the LBNL paper 21040, *Exegisis of Proposed ASHRAE Standard 119: Air Leakage Performance for Detached Single-Family Residential Buildings*; Sherman, 1986. See pp v-vi, Appendix pp 7-9, in particular formulas 4.2, 5, 6 and 7. Eq (1) is essentially eq. (7) from Sherman, with the addition of the term 60*0.055/144, which is added to provide the results as leakage area in SqIn, flow rate in CFM, and CFM50 instead of leakage area.] This equation is applied to every hour, filtered for heating (when Tout < 60) or cooling (Tout > 74). The CFM/CFM50 is summed for all the heating hours and cooling hours in the year, and the inverse (CFM50/CFM) is the N-factor for each season, respectively. This model is applied to a single-story home, and the values for taller homes are calculated as:

$$\mathrm{N}_{multi} = \mathrm{N}_{\mathrm{1story}} \times \mathrm{stories}^{-0.3} \qquad (2)$$

Hourly Methodology for Latent Multiplier

To estimate the increased cooling load resulting from infiltration, two values are calculated for every cooling hour (Tout > 74). The sensible load in btu/hour for 1 CFM of air is:

$$btu_{sens} = (T_{out} - 74) \times 1.08 \qquad (3)$$

Where Tout is the outdoor dry bulb temperature, and 1.08 is the btu/h per CFM of air. The total load in btu/hour for 1 CFM of air is:

$$btu_{tot} = MAX\left[btu_{sens}, \ (h_{out} - h_{ref}) \times 4.5\right] \qquad (4)$$

[4] In personal communication with the author dated 10/10/2013, Harriman agreed that the methods in his 1997 paper are inappropriate for residential infiltration cooling loads.

Where hout is the outdoor enthalpy in btu/lb; href = 28 is the indoor enthalpy (assuming 74F, 50% RH) and 4.5 is the conversion from enthalpy to btu/h per CFM of air. The total btu/h is not allowed to be less than the sensible btu/h for any cooling hour. The sensible and total btu/h loads are summed for all the cooling hours. The Latent Multiplier LM is the ratio of the total load to the sensible load:

$$LM = \frac{\sum btu_{tot}}{\sum btu_{sens}} \qquad (5)$$

[Citations:
Lew Harriman ASHRAE article
NBNL paper with infiltration model]